Exhibit 17

Examples of CW as the mode of last resort

personal experiences

In 1997, Shelley and I were on an extended trip around the world. During the months of late spring and early summer we were in North America. We traveled through the western States and the western provinces of Canada by car. We operated high frequency mobile using 100 watts. Wherever I had propagation on 3.8 MHz, I kept my regular Sunday night SSB schedule with friends back home in North Carolina. Because an 11 foot transmitting antenna is incredibly inefficient on 3.8 MHz, the stations in North Carolina often were unable to copy my signal. No problem! I simply switched to CW and gave them a report on our location and our progress.

I often operate portable using 100 watts. I have operated from Shelley's parents house in Duluth, Minnesota; my mother's home in Salem, Virginia; and from the North Carolina mountains and beaches. In each case, I have had to improvise a wire antenna. On these occasions, I make a practice of testing my installation by calling in with the Australians who operate on 3.7 MHz every morning. With only 100 watts and an improvised antenna, Australian is not easy on 3.7 MHz. Often, I cannot complete the contact on SSB, but the Aussies are good about listening for CW. Frequently, I have gotten through on CW when SSB failed.

On some occasions, my portable transceiver has been my Heathkit HW 9, a multiband, 4 watt radio. It is small and easy to carry. Like most such "QRP" transceivers, it is capable of CW only.

Amateurs often carry a hand held FM transceiver. CW can be transmitted with such a transceiver when FM cannot get through. The operator simple keys the dots and dashes with the push to talk switch. A dramatic example is described in the side bar contained in Exhibit 15.

18

Exhibit 18

Excerpt from the interview with
experimenter and moonbounce expert, Mike Cook

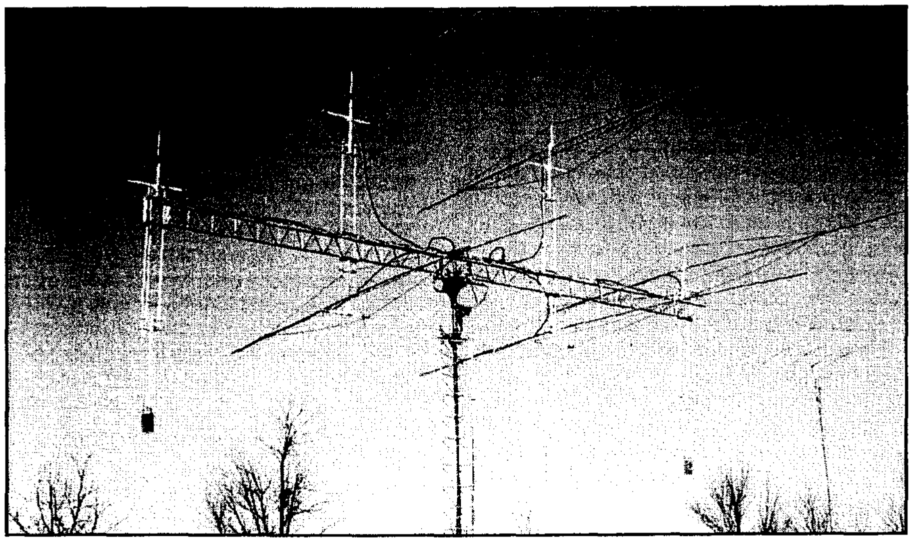
The highlighted text is one illustration of the use of CW by an amateur experimenter in his effort to advance the radio art. CW is the mode of choice because of its weak signal superiority.

By Steve Ford, WB8IMY

A Conversation With... Mike Cook, AF9Y

The first in an occasional series of interviews with hams who are making important contributions to our hobby.

Mike Cook, AF9Y, describes himself as an "incurable experimenter." What else would you expect from a ham who attempts to bounce signals off comets? Living in Huntertown, Indiana, Mike is the Communications Systems Engineering Director for ITT Aerospace Communications Division in Fort Wayne. He received his BSEE from Clemson University.



AF9Y's homebrew moonbounce (and "cometbounce"?) array. The antennas are 6 × 22 elements on 42-foot booms. The H-frame has a 50-foot cross boom made from 22-inch tower sections and 20-foot risers made from 14-inch tower sections. The array can be tilted ±50° in elevation, as well as the normal azimuth/elevation control. The whole tower tilts over with an electric winch to allow on-ground maintenance.

Q: I heard that you once issued a challenge to the ham community—$100 to anyone who correctly copies a specific moonbounce signal. How did the challenge work?

Yes, the $100 prize has been offered on my Web page (**http://www.webcom.com/af9y**) since 1995. Anyone who visits the site will find a one-minute digital recording (a WAV file) of a weak moonbounce station responding to my CQ. The downloadable file is called UNKN422.ZIP.

I couldn't complete the contact because the caller's signal was so far down in the noise. I couldn't even decipher one letter of his call sign during his one-minute transmission. Fortunately, the computer was recording the signal directly to disk. Using that recording, I attempted various signal processing techniques, combined with audio and visual methods, on and off for about a year before coming up with a reasonable guess. A telephone call to the station confirmed that my guess was correct. Since I had spent so much time attempting to decode the call sign, I wondered if anyone else could do it easier. That became the challenge.

The intent of posting the prize was to push the technology beyond the simple filtering techniques used by the standard DSP boxes sold today. A processing approach that can make this signal copyable to an average user would represent a major advancement in technology.

Q: Did you have a winner?

Yes. After two years and hundreds of submissions from around the world, Gary Huntress, a nonham, correctly identified the station. I felt sure that one of those super CW operators we all hear about would have the edge, so Gary's win was a surprise. Gary has agreed to keep the identity a secret so that the contest can continue for at least one more $100 award.

Q: Do you think it's ironic that a nonham won the prize?

Yes, especially since there were many more submissions by hams than nonhams!

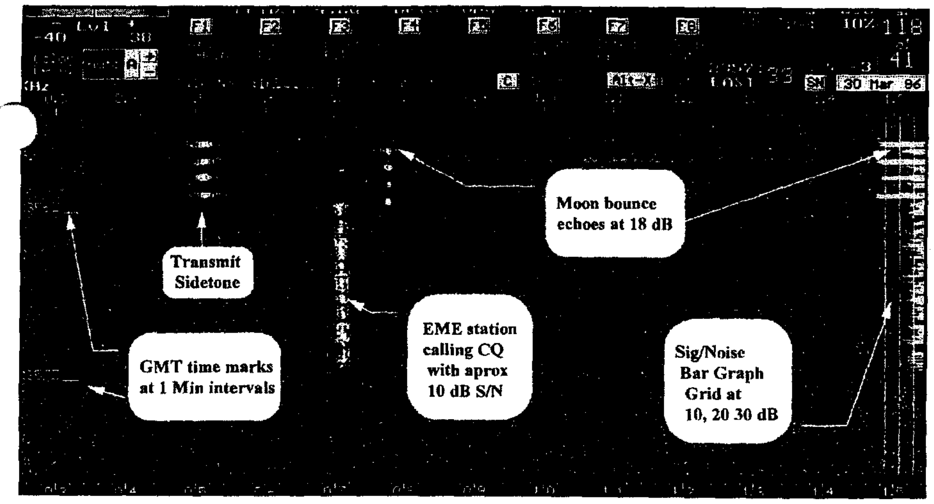
Q: Some hams believe that digital signal processing techniques will revolutionize weak signal work—particularly moonbounce. Is this true?

The revolution will come only with new waveforms. Digital signal processing techniques applied to our current CW, SSB and FM waveforms can provide modest improvements in perceived quality, but little in real information gain. The UNKN422 file is a good example. A good CW operator can usually pick my call out of the noise using either a 500-Hz analog audio filter or "state-of-art" DSP 20-Hz filter. The human brain can filter at between 20 and 50 Hz, so the DSP filter is not providing any real information gain. I am not saying that a DSP filter has no value. It can make listening in noise less tiring and for some operators it may make the difference in copying a few extra letters.

Q: Will DSP ever make it possible for hams with small stations to work moonbounce?

What constitutes a small station for moonbounce? I believe we should be working toward an approach that allows a two-way exchange of calls during a 30 minute period with the following minimum system

See Exhibit 16



A sample of the *FFTDSP* software (with labels added by Mike) as seen on his Web site at **http://www.webcom.com/af9y**.

Mike Cook and the twin 70-cm helix antennas he used to receive signals from the Mars Global Surveyor.

at both ends of the link:

- 200-W transmitter output
- A pair of 10-foot antennas, or one 20-foot antenna
- 0.5 dB NF receive system

It appears that 432 MHz offers the greatest opportunity to meet this objective with current technology. Still, a processing gain of approximately 15 dB over the typical CW waveform would be required for a better than 50% chance of completion.

Polarity rotation has a major impact on moonbounce operation. Signals are very likely to arrive at angles other than the receive antenna polarity. Leif Asbrink, SM5BSZ, has spearheaded a small revolution in this area by developing practical polarity controlled antenna/receiving systems. We need a similar breakthrough in the waveform area. Phil Karn, KA9Q, and Tom Clark, W3IWI, have studied and proposed several good ideas, but nothing has yet been demonstrated.

Q: Tell me about the* FFTDSP *software you've developed. What can the average ham do with it?

With help from W9HLY, the *FFTDSP* program has evolved over several years. It allows an IBM compatible computer to "see" weak radio signals. It interfaces to your radio by connecting the receiver audio output to the computer sound card. A continuous running color map of the sound is displayed and updated every half second. The map shows sound frequency and intensity level. This type of map is called a spectrogram and will show signals far below the level detectable by the ear. SETI searches as shown in the movie *Contact* often use this type of display.

Potential uses are:

- Find a weak CW signal while in the receiver full bandwidth mode (2.4 kHz). The signal can then be centered for better copy with external audio/DSP filters.
- Monitor beacons over several hours and then review drift and peak receive periods.
- Check receiver alignment within 2 Hz using WWV audio
- Monitor meteor burst Doppler shifts and signal strength
- N6EGQ has used it to detect earthquakes in California!

A demo version of the *FFTDSP* program is downloadable from my Web page. It only runs for about 60 seconds, but it gives you a small taste of what it can do. Hams can buy the registered version from me. All the details are on the Web page.

Q: I heard that you managed to copy the 70-cm beacon signal from the Mars Global Surveyor. How did you do it? How far away was the spacecraft when you received the signal?

NASA provided data on the expected signal level at Earth during a planned Mars Global Surveyor transmitter test on November 25, 1996. My calculations showed that the signal would be too weak for audio detection with reasonable-sized antennas. Using a pair of 5-foot helix antennas and a mast mounted preamp, the signal level would be less than –171 dBm! As a comparison, my "mystery moonbounce" signal is barely detectable by ear and it's approximately 16 dB stronger.

On the plus side, the continuous carrier from MGS was ideal for detection with the *FFTDSP* program. An integration feature of the program was used to further increase the sensitivity for carrier detection. My tests showed that signals as low as –179 dBm could be detected over a 1300-Hz search window.

When the transmitter was activated at 1413 UTC, I was delighted to see a clear carrier line forming in the *FFTDSP* display. The line clearly showed the expected Doppler shift, as well as the varying signal strength as the MGS antenna rotated. During the test, the satellite was about 3.5 million miles from Earth. That's seven times the round-trip distance to the moon!

Pictures of the received signal, as well as construction information on the helix antennas, are also available on my Web page.

Q: I know that you've attempted to bounce signals off the tails of comets. Any success?

Not yet. During the March 1996 appearance of comet Hyakutake, I made an attempt using my moonbounce array and the *FFTDSP* program. A continuous 1500-W, 144.1 MHz carrier was transmitted for 45 seconds. The receive period was 75 seconds. Any reflection from the comet should have been visible as a line trace during a portion of the software's receive window. Nothing was seen. The comet ionization was probably too poor at VHF.

Q: How do you feel about the future of Amateur Radio? Where are we heading?

I'm a little worried that Amateur Radio is not attracting the creative talent it did years ago. Instead of blaming Internet and computers for our decline, we should be embracing them as tools to attract and inspire the next generation. The lines that used to separate computer hobbyists and hams are dissolving; the hobbies are beginning to merge. Huge numbers of hams now have e-mail addresses and surf the Web regularly (or have Web sites of their own). I see this as a positive development, not as a threat to Amateur Radio.

Sometimes we're our own worst enemies. We need to reduce the in-fighting on issues like spread spectrum, CW and so on. We should set our differences aside and combine forces to fight the real enemy, which is the continued government sell-off of the RF spectrum. QST

Exhibit 19

High speed CW and meteor scatter

The attached article from *QST* demonstrates how CW is used in another area of cutting edge amateur experimentation. Note that the CW must be recorded and then slowed down to 30 wpm. The operator then copies the signal by ear. Amateurs typically use CW to advance the radio art in experimental communications.

By Jim McMasters, KD5BUR

High-Speed CW and Meteor Scatter—An Exciting VHF DX Medium!

European hams have been bouncing ultra-high-speed CW signals off the fiery trails of meteors for years. Now American hams are discovering the excitement. You don't need a super VHF station, you don't have to be a CW whiz and you don't even need to wait for a meteor shower!

Does your 2-meter all-mode radio stay tuned to 144.200 MHz most of the time, generating the all-too-familiar white noise of an idle band? Do you occasionally call CQ only to be rewarded by the same white-noise response? Tropo openings aren't everyday occurrences on 2 meters, and E-skip conditions are all but nonexistent.

How would you like to put your all-mode radio to work making DX contacts whenever you want? All you need is a good dose of persistence and an introduction to high-speed CW (HSCW) via meteor scatter (MS). Since I began using this mode in November 1997, it has put excitement back into my weak-signal VHF operations. My HSCW station is modest: a Yaesu FT-290 mobile/portable all-mode transceiver driving a 100 W brick amp into a Cushcraft 17B2 Yagi antenna. If you are a VHF DX hound/grid hunter, then this may be just the thing to fuel your fire.

HSCW is Not New!

HSCW has been in use in Europe for a couple of decades. European VHFers often work three or four different stations per hour, without the benefit of a meteor shower, using this mode. During major meteor showers, several DXpeditions may be conducted by teams of operators to activate rare grid squares throughout Europe and western Asia. Grid hunting with HSCW is very popular there. One operator notes that he has worked "...hundreds of new grids (now at #651...) over the years."[1] HSCW activity has been described several times in the pages of *QST*.[2]

[1]Notes appear on page 39.

This sounded like something I really wanted to try. But, I wondered, how could it be possible to work new grids on 144 MHz at almost any hour, almost every day? In order to understand, I first had to learn a little bit about how QSOs are made using meteor scatter. Let's begin our quest for "anytime VHF DX" with a brief review of meteors themselves.

Space Invaders

Meteors are small particles of matter, most only the size of a grain of sand. Some are the leftovers from the formation of our Solar System; others are thrown off by celestial bodies such as comets. When the Earth passes through a high concentration of cosmic debris, we have a meteor shower.

The secret of HSCW meteor-scatter success is the fact that debris is falling into our atmosphere *constantly*. The Earth sweeps up hundreds of tons of space matter each year. On any given day, over *12 billion* meteors impact the atmosphere! The vast majority of these meteors are what are called "sporadic," or random, meteors because they aren't numerous enough to be noted as a shower. The large number of these random meteors makes it possible for you to work new VHF DX almost whenever you want.

Meteors enter the atmosphere and begin burning at heights ranging from 110 to 100 km (66 to 60 miles), depending on how fast they enter. This is about the same height as the E layer of the ionosphere, the region of our atmosphere that gives us our familiar E-skip openings! Thus, the distance over which we can work is about the same for both meteor scatter and E skip. The faster the meteors enter, the more quickly they incinerate (and at higher altitudes).

As meteors burn up in the atmosphere, they form either *underdense* or *overdense* trails. Overdense trails typically create ionization so intense that, to radio waves, the trail looks like a cylindrical metallic reflector. These trails strongly reflect radio signals, sometimes for as long as a minute or more, even long enough to complete several contacts using SSB. Unfortunately, overdense trails and the "bursts" they produce are uncommon except near the peaks of meteor showers.

Underdense meteor trails, on the other hand, provide only very short reflections (commonly called *pings*). The ionized trail tends to scatter radio signals rather than reflecting them. While underdense trails only last a fraction of a second and seldom reflect more than a syllable or two of voice, they are extremely common. As you're reading this sentence, multitudes of underdense trails are flashing into existence miles above your head, then disappearing.

Fast-burning underdense meteor trails were discovered by the first ham operators to make 2-meter contacts via meteor scatter. They used high CW keying speeds in their tests. The keying speeds were well beyond what any human could possibly decipher, so they recorded the signals on audiotape and reduced the speed by 50% or more for decoding. They soon learned that these short-lived meteor trails could be used to relay quick bursts of information.

HSCW—How Fast is "Fast"?

Having been absent from ham radio for more than 20 years, I was curious how "weak signal" VHF work had changed. I first found

(over)

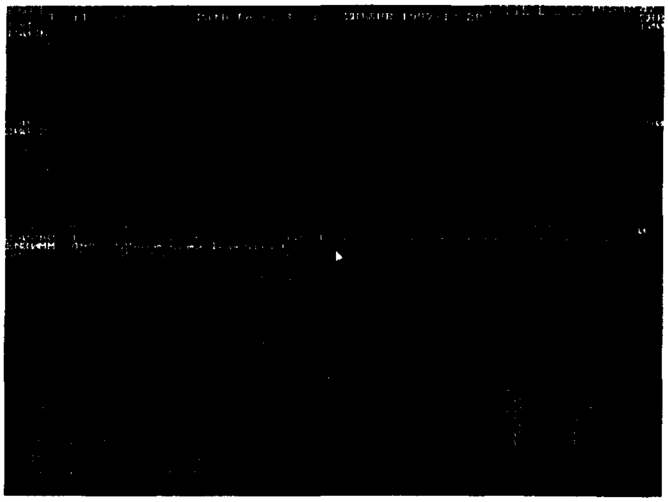


Figure 1—The *MSSOFT* "geometry" screen displays data such as meteor trail efficiency, path loss, azimuth and elevation of the shower, beam heading and distance to station. The date can be changed easily from this screen to watch the changes occur in the shower geometry. The distant station's "locator" or grid can also be changed to recalculate a new set of values.

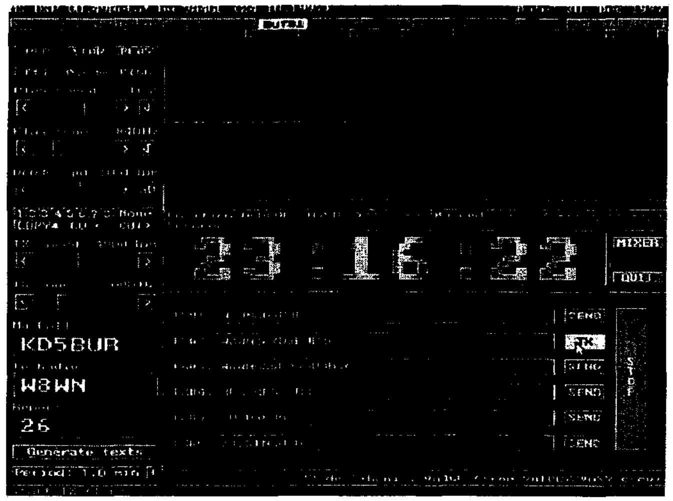


Figure 2—*MS DSP*, written by Tihomir Heidelberg, 9A4GL, is popular among HSCW operators. Above the digital clock is the main receive buffer. When a burst is heard, the operator marks the buffer spot and saves the burst to one of eight buffers above. During the next transmit period the saved buffer areas are replayed while varying the speed and tone with controls to the left. Transmit data is changed (lower left) and selected as necessary (lower right).

references to HSCW while browsing the Internet. Time after time, I encountered Web sites mentioning this "new" mode of communication using meteor scatter, with some site authors making astonishing claims of working new grids on 144 MHz almost every day! This mode of communication was more successful than anything I had ever heard of. One operator commented, "...you don't need major showers for an MS QSO! If I make a sked for tonight or tomorrow morning in the 650-1000 mile range, we are 95% sure to complete the contact."[3] The more I read, the more eager I became to try this "new" mode.

Just how fast is HSCW? Here are some typical examples for comparison:

Conversational CW	15 WPM
Contest-style CW	30 WPM
SSB	200 WPM
Slow HSCW	200 WPM
Fast HSCW	800 WPM
Very fast HSCW	1200 WPM
Ultra fast HSCW	1600 WPM

You can see that even slow HSCW is just as fast as most SSB operators care to speak, except, possibly, those whose occupation is auctioneering!

Hardware and Software

Traditional hardware for HSCW calls for modified tape recorders for recording and slowing down received signals, and memory keyers (with audio oscillators for tone-injection keying) for transmitting high-speed CW. There are hardware interface circuits readily available to utilize such equipment.[4] With my background in computers, I was immediately interested in the newly available software offered as shareware. I had just purchased a new state-of-the-art computer complete with a true SoundBlaster sound card, which I had little doubt would work for this application, and so I decided to try the computer method. (As you'll see later on, however, you don't need a powerful PC like mine to work HSCW.)

As I surfed the Web it became apparent that there were several ways to transmit and receive HSCW using ordinary home computers. At first I had a concern about whether my rig could handle such fast keying speeds; but then I found that most hams were keying their rigs by injecting a keyed 2000 Hz tone directly into the mike jack while operating in the USB (upper sideband) mode. This is mode *J2A* and is virtually equivalent to pure CW.

There are programs that will handle the transmitter keying only and do not need a sound card, although an audio oscillator and a simple interface are required. One such program is *MSSOFT* by Ilkka Yrjola, OH5IY.[5] This shareware program also features an MS scheduler, whereby upcoming schedules may be entered and even integrated into an automatic transmit sequence. Another highlight of this program is the fantastic MS path efficiency analysis section (see Figure 1). The documentation that comes with *MSSOFT* is a good education on both the program itself and meteor scatter work in general.

Another program, written by Al Van Buren, K7CA, sends a keyed tone to the computer's speaker, which can be tapped off and fed into the mike jack.[6] Still another way to go is to use a memory keyer, such as the CMOS Super Keyer, which is capable of up to 4950 LPM (*QST*, August 1995), coupled with a suitable audio oscillator.[4] The keyer will take care of the transmit side and a modified cassette tape recorder can handle the receive recording duty. European experience dictates that the modified cassette tape recorder method will work up to a speed of approximately 1500 LPM. There is a German digital tape recorder now available that a number of Europeans are using.[8] As none are in use over here, it is not known how well this device will work for North American style HSCW operation. I should also mention that there is a group of dedicated US operators who are studying the possibility of developing affordable non-computer hardware to operate HSCW.

When it comes to computer programs, which handle both transmit and receive simultaneously on one machine, there are few choices at the present time. However, this method appears to be the best for most computer-equipped North American hams.

The program that is currently used by the majority of those on HSCW in North America is *MS DSP* (see Figure 2).[7] This is a DOS-only program that uses the Creative Labs SoundBlaster-series sound cards to convert and record the received signal, save operator-marked pings, and allow the immediate playback of the saved signals at reduced speed (no tape recorders necessary!). The replay speed can be varied by a factor of up to 60 times, which could slow a 480 WPM ping down to as slow as 8 WPM, 1000 WPM ping down to about 16 WPM, or a 1700 WPM ping to about 30 WPM! It features an "up-converter" that heterodynes the very low audio pitch of the slowed-down CW note to a tone more easily heard. While the saved signals are being reviewed, this program is also transmitting the operator's data. The many functions of this program can be controlled by either the keyboard or mouse, and transmit speeds of up to 1700 WPM are possible. Data to be transmitted is

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Exhibit 20

Low frequency amateur band in Europe

In Europe, amateurs have been granted privileges on low frequency. On such frequencies, practical antennas are extremely inefficient because they are limited to a tiny faction of the optimum one-quarter wavelength. Effective radiated power is less than one watt. The use of CW is the mode of choice for those experimenting on these frequencies. The attached article from *QST* is illustrative.

By Peter Dodd, G3LDO

Exploring 136 kHz

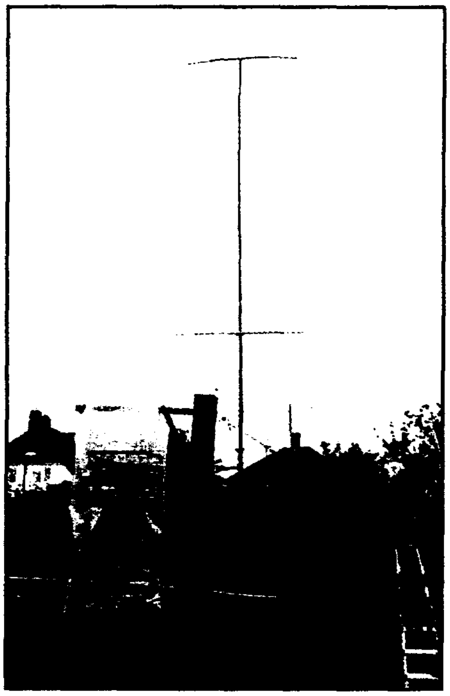
Tired of cookie-cutter QSOs and armchair copy? Want to work DX stations a hundred miles away? Like to get up before dawn? Low-frequency hamming is all this—and more! European hams are getting their feet wet on the new 136-kHz band. Will the US be next? Here's a look at what we might expect.

On January 30, 1998, a new ham band—135.7 kHz to 137.8 kHz—was made available in the United Kingdom. The new 136-kHz band, as it's called, produced a lot of activity in the scant few months since its inception. Many UK ops who had gained construction and operating skills at 73 kHz were up and running.[1] The Crawley Radio Club, G3WSC (operated by G3KAU, G3GRO and others), have put up a large antenna and, with an output of 700 mW ERP, have worked a lot of DX. At the time of this writing G3YXM, who runs 800 W to produce nearly 1 W ERP is one of the UK's leading 136-kHzDXers. The band has also been allocated in several other European countries (see the sidebar, "The 136-kHz Bandwagon").

The ARRL is pursuing a similar LF allocation for American hams, who may soon be joining in the fun "way down under" (see item 2.1 of the ARRL Executive Committee Minutes on page 55 of September 1998 *QST*).

A QSO on 136 kHz

It's six in the morning as I walk down to the shed at the bottom of the garden. The small shelter has been converted to my LF shack.



The construction of the loading coil and the antenna. The coil is 1-mm plastic-covered wire wound on plastic lattice fencing, which is rolled into a coil former of the appropriate size (12 inches in this case). The coil is covered by a clear plastic bag to protect it from the weather.

LOWfing in the USA

If you're a US ham, you can't chat on Europe's new 136-kHz band, but you can get your feet wet on the "160-190 kHz Experimenter's Band," which has been populated by hardcore domestic VLF enthusiasts (affectionately called LOWfers) for years.

Power output and antenna restrictions abound, which encourages ops to listen for each other's CW beacons—but contacts are possible, even over relatively long distances. At any rate, with at least the possibility of an American LF allocation you might want to start experimenting in advance.

The Longwave Club of America has long been a focal point for LOWfers. For info write or e-mail to 45 Wildflower Rd, Levittown, PA 19057; 215-945-0543; **naswa1@aol.com**. Or, check out the club's magazine, *The Lowdown*, and numerous informational offerings at **http://members.aol.com/lwcanews/index.html**.

For information on VLF transmitters and receivers, point your Web browser to Curry Communications' excellent VLF site at **http://www.fix.net/~jparker/currycom.htm**.

Equipment used for 73 kHz and 136 kHz by the author. In the foreground is the tuning/matching coil. The chassis contains a 250-W audio amplifier module (mounted vertically) driven by a modified signal generator. The chassis also contains transmit/receive switching and a tuned input filter for the receiver. The TS-850S is used for receiving and the laptop PC is used for keying the transmitter on very slow Morse transmissions.

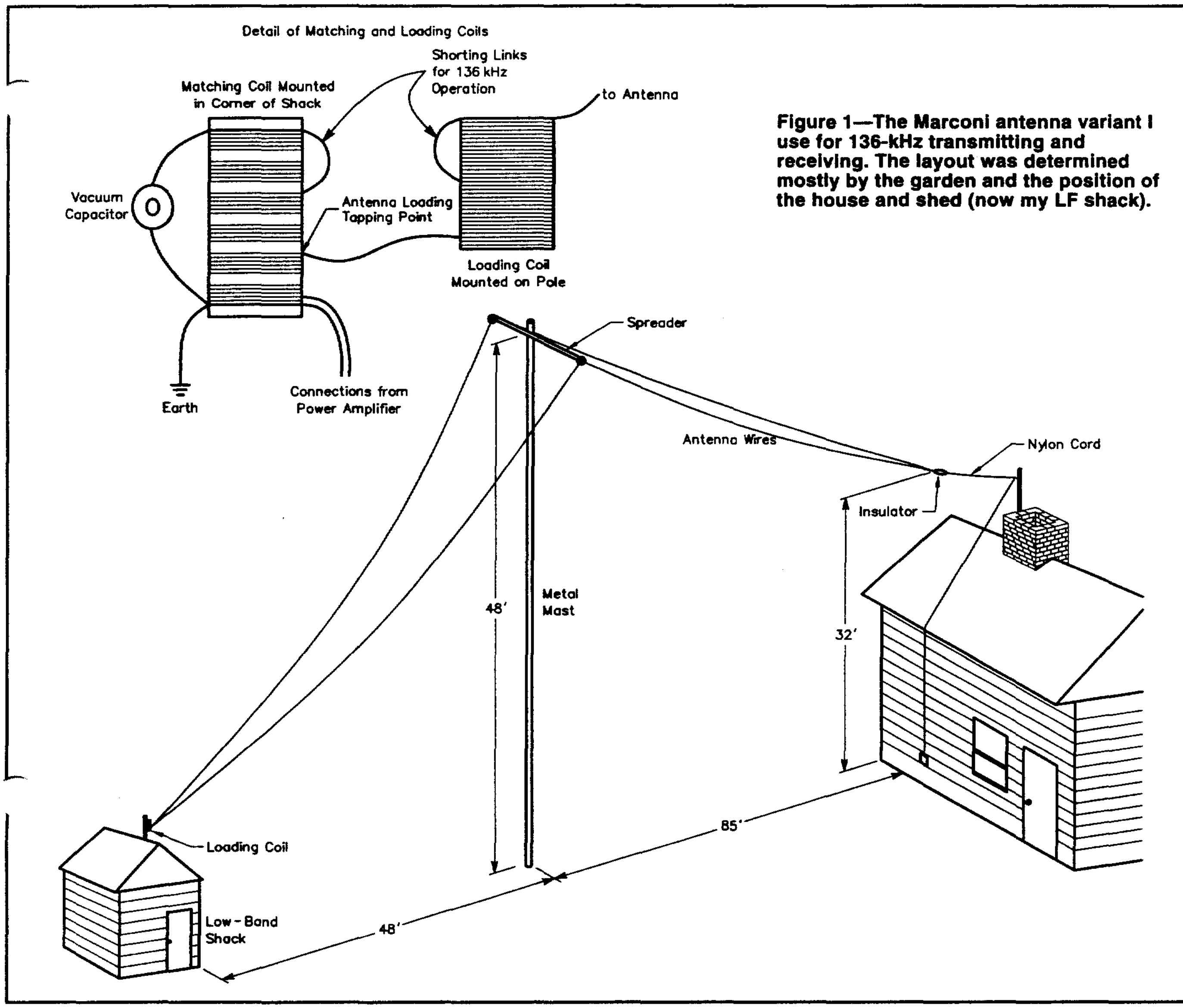


Figure 1—The Marconi antenna variant I use for 136-kHz transmitting and receiving. The layout was determined mostly by the garden and the position of the house and shed (now my LF shack).

Inside is where I'll join the 136 Early Bird Net.

I switch on the TS-850S—which does double duty as my 136-kHz receiver—and slowly tune down from my normal transmitting frequency of 137.6 kHz. The only signals present are a couple of commercial RTTY carriers at 136 and 136.7 kHz, battling through a background of static and the machine-gun rattle of the spurious sidebands produced by a 100-kHz Loran transmitter. There are no amateur stations, so I decide to call CQ.

I check the frequency and drive level on my modified RF signal generator and switch on the audio amplifier, which doubles as a final amplifier. Holding down the key, I adjust the tuning coil's vacuum capacitor for maximum antenna current, which peaks at 4 A. I then switch on the automatic keyer, which is programmed to send CQ, while checking the amplifier's FET current and RF output. The antenna current is varying by 200 mA or so, but I know from experience that the fluctuation occurs because the antenna wires move in the wind. The tuning can be quite critical.

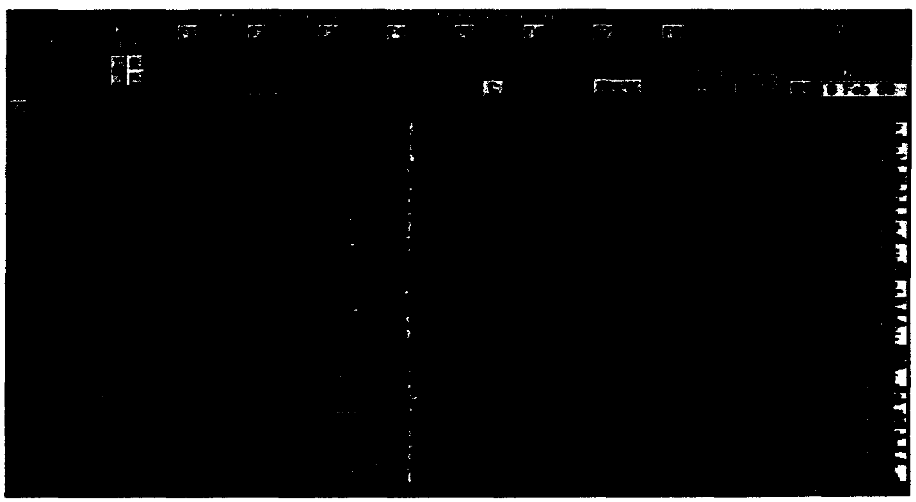


Figure 2—An FFT display using software developed by Mike Cook, AF9Y. On the horizontal scale (along the top) 0.05 = 136.5 kHz and 1.0 = 137.0 kHz. The slow CW signal from G3XDV can be seen at 136.83 kHz (the crude letters of the call sign are superimposed in photo-paint). The vertical dotted lines are spurious sidebands from the 100-kHz Loran transmitter at Lessay, in northern France.[3]

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Exhibit 21
US "LowFer" band

"Lowfers" refers to experimenters operating on the unlicensed 160 to 190 KHz band. The attached article is a chapter from *The World Below 500 Kilohertz* by Peter Carron, Jr., W3KDV (Universal Radio Research, 1992). It demonstrates that CW is the mode of choice by those experimenting on such frequencies.

4

LOWFERS

LOWFERS is an acronym for LOW Frequency Experimental Radio Station. LOWFERS operate between 160 and 190 kHz (the 1750 meter band) without a license. Part 15 of the FCC Rules and Regulations allow them to do so.

What do they transmit? When do they transmit? Who can hear them? What are their power limits and other restrictions? Low Frequency Experimental Radio Stations are as their name implies - experimenters, or hobbyists. They are limited by law to one watt of input power to the final amplifier and their antenna length, including transmission line, may not exceed 15 meters. These are the primary restrictions; several others will be discussed shortly.

Most of these hardy souls operate their stations as beacons (using Morse code), some 24 hours per day 365 days per year, others on just weekends or at night, and others simply when the mood strikes them. Since no license is required, no callsign is assigned by the FCC and therefore one must be chosen by the station owner. The most common callsigns used are comprised of the owner's initials or the letters following the numeral in his or her amateur radio call (if the station owner is also a ham). Sometimes the address of the station is given after the callsign so listeners know where to send reception reports.

Although operated as beacons, LOWFERS also make contacts amongst themselves. CW is the mode used most often, but sometimes SSB or AM are employed. Experiments with Coherent CW have also been tried. For those unfamiliar with this term, Coherent CW (CCW) is a form of CW that makes use of a highly-accurate frequency source, such as WWVB, for synthesizing the local oscillator frequencies at both the transmitting and receiving ends. Also, the exact code speed of the transmitter is stipulated in advance. By knowing the code speed and having the oscillators at each end synchronized, the receiver can use a filter of very narrow bandwidth. Optimizing the receiving function in this manner can result in more than a 20 dB improvement in signal strength.

There is one source of information on LOWFER activity that is a <u>must</u> for anyone interested in this unique hobby. The Longwave Club of America (LWCA) was organized "to promote DXing and experimenting on frequencies below 550 kHz and activity on the 1750 meter band." It is a club of high-standing and one that has been in existence for years. Many of its contributors provide excellent technical articles concerning LOWFER and other activity on the longwaves. See the Reference Section for the address of this club and

any other organizations, publications etc. mentioned throughout this text.

Another information source on this activity is "The Low and Medium Frequency Radio Scrap Book" by Ken Cornell. It is <u>the</u> book on technical information concerning LOWFER receivers, transmitters, antennas and other gear.

No one knows for sure how many LOWFERS are currently in existence. The Northeast and California contain the highest populations, but stations are known to exist in Oklahoma, Nevada, New Mexico, South Carolina, Illinois and Florida to name just a few additional states. The numbers of this group have increased appreciably in recent years and indications are they will continue to do so. Despite the low power limit allowed, reception from a distance of 25 to 75 miles is common with ideal conditions allowing signals to be heard from several hundred miles away. On occasion, reports of signals over 500 miles distant have been recorded.

The equipment needed to transmit is relatively simple and inexpensive, and matters are uncomplicated in general. Other than the power level and antenna size limits mentioned previously, only a few other restrictions apply. Spurious emissions outside the 160 to 190 kHz segment must be suppressed by at least 20 dB and no interference may be caused to other services. The latter restriction is seldom a problem since the "other" services are likely to be CW or RTTY stations running thousands of watts!

To fully comply with FCC rules allowing transmission on this band, one last step must be taken. The owner of said radio station "shall attach to each such device a

ETC.

Exhibit 22

Amateurs design a high efficiency Class E amplifier

This is part two of a two-part article from *QST*. It describes the design and construction of a new type of amplifier that is highly efficient, small, light weight, and capable of producing high power from a few watts input. The project began as a senior thesis at Caltech. It became a research fellowship project funded by the ETO Corporation. A description of the history, funding, and support for the project appears in the final paragraph of the article under the rubric, "Acknowledgments." **The amplifier is capable of transmitting CW only**. There would have been no incentive for this project if amateurs did not operate on CW.

Only part 2 of the article is attached because I could not immediately find the May 1997 issue of *QST*, in which Part 1 was published.

By Eileen Lau, KE6VWU; Kai-Wai Chiu, KF6GHS; Jeff Qin, KF6GHY; John Davis, KF6EDB; Kent Potter, KC6OKH; and David Rutledge, KN6EK

High-Efficiency Class-E Power Amplifiers—*Part* 2

Class-E operation permits low-cost MOSFETs to develop considerable power.

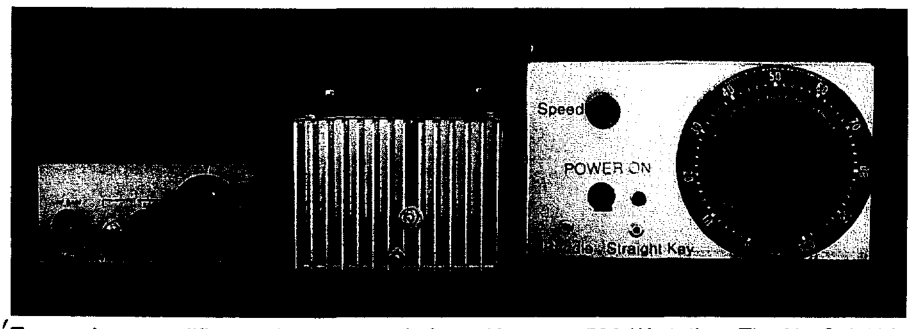
Last month[7] we talked about Class-E amplifier fundamentals and began construction of a 40-meter unit. Now we'll tackle the power supply, keyed-waveform shaper and develop some power.

A Keyed Power Supply

Nonlinear Class-E operation sharpens the CW keying envelope, causing annoying key clicks. To prevent this, we key the power supply to shape the supply voltage. A separate 4×7×12-inch (HWD) enclosure houses the dc supplies, a stretcher circuit that delivers a stretched pulse to the driver and a shaper that produces the shaped pulse for the amplifier. Figure 8 shows how these circuits connect.

So that the RF drive does not end before the shaping pulse, the keying pulse to the NorCal 40A driver is stretched a few milliseconds. The stretcher (Figure 9) takes a keyer's CMOS logic signal and provides a buffered keying waveform to the shaper and a stretched keying waveform to the NorCal 40A driver. Dc supplies (Figure 10) provide 12 V dc to run the ICs and 0 to 120 V dc for the amplifier. A wave shaper (Figure 11) gives this 0 to-120 V dc supply voltage a controlled rise and fall time to avoid key clicks. Figure 12 shows the keyed power supply with its cover removed.

There are other advantages to using a keyed power supply to control the output power. The amplifier power dissipation is low at all supply voltage levels, so that loss is kept low throughout a keying pulse. Because the keyed power supply also acts as a solid-state TR switch, a relay is not needed. This is because the supply voltage is zero except during key down. (This feature works well with the NorCal 40A, because it, too, does not use a relay for switching.) At zero voltage, the drain-to-gate capacitance in a MOSFET is quite large, and the signal from the antenna is fed through the amplifier with a loss of only about 7 dB. The NorCal 40A receiver sensitivity is excellent,[8] and a 7 dB signal loss does not hurt reception at all. A 7-dB loss degrades the MDS to −130 dBm, still far below typical 40-meter antenna noise levels of −90 to −110 dBm. On the positive side, with 7 dB attenuation, the receiver is less susceptible to intermodulation distortion from other signals in the 40 meter band. In addition, the amplifier reduces AM broadcast signals by about 20 dB. The 7-dB loss does need to be made up at the audio end. For this, we mount a 2-inch-diameter speaker in a cardboard mailing tube cut to



Transceiver, amplifier, and power supply for a 40-meter, 500-W station. The NorCal 40A transceiver driver is on the left, a 500-W amplifier is in the center and the power supply on the right. The amplifier's heat sink and transistor mounting screws are visible. The large dial controls the variable autotransformer, varying the RF output power.

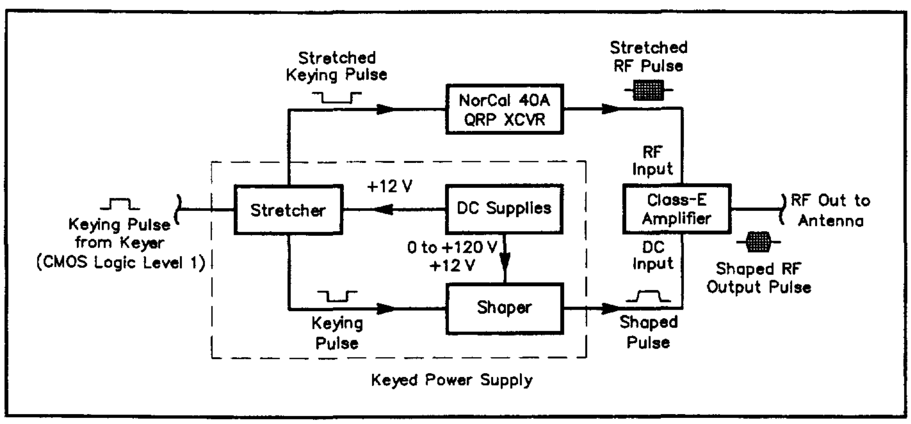


Figure 8—Block diagram showing the connections between the stretcher, dc supplies, shaper, NorCal 40A and the Class-E Amplifier. The stretcher, the dc supplies, and the shaper are in the keyed power supply. Power supply keying is done by a Curtis keyer IC (not shown) that provides a CMOS logic-level 1 during key down. The Curtis keyer IC and application note are available from MFJ Enterprises Inc, Box 494, Mississippi State, MS 39762, tel 800-647-1800, 601-323-5869, fax 601-323-6551; e-mail **mfg@mfjenterprises.com**; WWW **http://www.mhjenterprises.com**.(Keyer circuits using Curtis ICs can be found in recent editions of *The ARRL Handbook.—Ed.*)

[7]Notes appear on page 42.

(Pages Omitted)

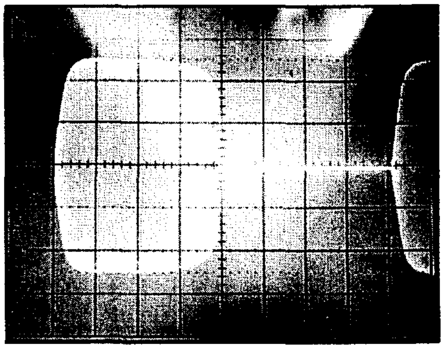


Figure 14—Keying waveform of the 500-W amplifier at 30 WPM. The horizontal axis is 10 ms per division. The rise and fall times are about 3 ms.

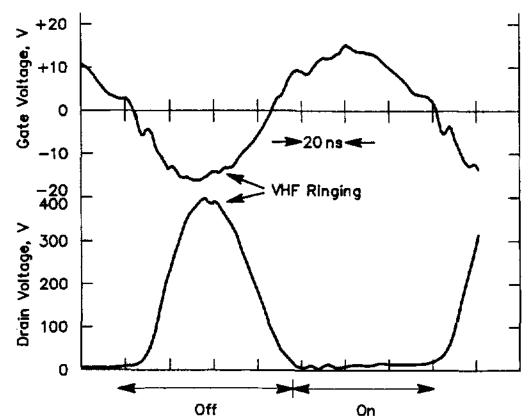


Figure 15—Drain waveform and ringing. Oscilloscope trace of the gate and drain voltages of the 300-W amplifier with 3 W drive. The dc supply voltage is 120 V; the input SWR is 1.6:1. Time scale is 20 ns per division; the transistor off and on times are shown. The transistor is off when the gate voltage is below the threshold, typically 4 V, and on when the gate voltage is several volts above the threshold. Peak gate voltage is 16 V, and the peak drain voltage is 400 V, safely within the manufacturer's ratings of 20 and 500 V, respectively.

the amplifier is keyed. R2 of Figure 9 determines the stretch in the pulse that keys the NorCal 40A, so that it does not stop transmitting before the end of the shaped pulse. We recommend using a keyer with adjustable weighting to offset the pulse stretching. The potentiometer settings interact somewhat, and there are variations at different sending speeds, so it is best to set them at the speed you commonly use. Adjust the controls for rise and fall times between 2 and 5 ms, and for a smooth keying envelope. Figure 14 shows keying at 30 WPM with rise and fall times of about 3 ms.

VHF Ringing

In many Class-E amplifiers, ringing in the VHF range can be seen on the gate and drain waveforms (Figure 15). This ringing can be quite pronounced, with bumps several volts high on the gate or drain or both. The bumps disappear when the RF input is removed, and that is why we refer to this as *ringing* rather than *oscillation*. We have compared measured spectral plots with *PSPICE* simulations and believe that the waves are driven by the sudden turn-on and turn-off of the transistor, acting rather like the gong of a bell.

We notice two distinct time periods and frequency ranges for the ringing. During the time the transistor is on, the ringing frequency is about 80 MHz. This appears to be a resonance of the external drain capacitor combined with the internal inductance of the capacitor and the transistor and may indicate a mismatched load. The on-ringing is usually small if the load is matched so that the drain voltage comes smoothly to zero before the transistor turns on.

The ringing while the transistor is off covers a broad range of frequencies—from 130 to 210 MHz. If the output low-pass filter is removed, the ringing can be seen easily on a spectrum analyzer at levels between −40 and −60 dBc. The off-ringing appears to be caused by a resonance of the external drain capacitor and its internal inductance, together with the transistor's internal drain capacitance and its inductance. The internal drain capacitance varies greatly with the drain voltage, so that the frequency is modulated as the drain voltage rises and falls. The low-pass filter reduces these harmonics to the −70 to −80 dBc range.

On the Air

The amplifiers meet the FCC requirements for spectral purity [confirmed in the ARRL Lab—*Ed.*]. NorCal 40A designer Wayne Burdick, N6KR, emphasizes that it is important to correctly tune the bandpass filter following the transmit mixer to minimize spurious emissions from the NorCal 40A.[11]

These amplifiers are excellent for chasing DX, schedules and "ragchews," particularly at this low point of the sunspot cycle. The amplifiers require no warm-up, no tune-up, and produce no fan or relay noise. We can vary the power from 1 W to full power via the variable autotransformer. The antenna SWR should be 1.5:1 or better because the amplifier is not protected against large mismatches. With a high SWR, the transistor will probably overheat. Check the dc voltage when the amplifier is delivering full power to the antenna to ensure that it remains between 115 V and 120 V. Readjust the coils if the voltage is too high or too low.

Our most common problem has been a poorly mounted PA transistor. If the transistor is not flat against the heat sink, heat transfer is poor and the transistor becomes quite hot; efficiency suffers (becoming usually less than 85%) and the amplifier may not reach full power. The output power may also drift downward, a sign that the transistor temperature is increasing and that the transistor is under stress.

Component temperature can be a good diagnostic tool. For the 500-W amplifier, our experience is that for CW QSOs longer than 30 minutes, the temperature of C3, C5 (Figure 5) and the heat sink rises to about 60° C. For the 300-W amplifier, the heat-sink temperature is about 50° C. This is hot to the touch, and it can be checked with a lab thermometer. The temperature will vary according to your operating style, and if the temperature is higher than you like, you can add a fan.

The Future

We see room for improvements: protection against antenna mismatches and employment of an inexpensive keyed *switching* power supply that is as lightweight as the amplifiers. Finally, it would be interesting to develop Class-E amplifiers for the other bands. We have built a 250-W amplifier for the 20 meter band that exhibits an efficiency of 88% with 10 W drive. We believe that Class-E amplifiers provide amateurs with good building challenges and operating fun at modest cost.

Acknowledgments

This work began as senior theses by Joyce Wong and Meng-Chen Yu at Caltech, and many of their ideas appear here. John Davis was supported by a scholarship from the James Irvine Foundation and the Army Research Office. Eileen Lau, Kai-Wai Chiu, and Jeff Qin received Caltech Summer Undergraduate Research Fellowships funded by the ETO Corporation and the Caltech Gates Grubstake Fund. We appreciate the help from all the people at the ETO Corporation, particularly Dick Ehrhorn, WØID; Don Fowler, W1GRV; Tim Coutts; Chip Keen and Frank Myer. Mitsu Sakamoto, JA4FVE, of Kurashiki, Japan, sent us off-the-air recordings over the Internet. We would like to thank Wayne Burdick, N6KR; Wes Hayward, W7ZOI; and Bill Bridges, W6FA, for their advice.

Notes

[7] Eileen Lau, KE6VWU, et al, "High-Efficiency Class-E Amplifiers—*Part 1*," *QST*, May 1997, pp 39-42. The amplifier enclosures are 3⅛×4⅛×7⅛ HWD.

[8] Rick Lindquist, KX4V, "Low-Power Transceiver Kits You Can Build," Product Review, *QST*, Jun 1996, pp 45-50.

[9] See J. B. and R. V. Heaton, "An Electro-Acoustic CW Filter," *QST*, Apr 1983, pp 35-36; Wally Millard, K4JVT, "A Resonant Speaker for CW," Hints and Kinks, *QST*, Dec 1987, p 43; and Richard Clemens, KB8OAB, "More on Resonant Speakers," Hints and Kinks, *QST*, Jan 1989, p 37.—*Ed.*

[10] David Newkirk, WJ1Z (now W9VES), and Rick Karlquist, N6RK, "Mixers, Modulators, and Demodulators," *The 1996 ARRL Handbook*, Chapter 15, p 15.22.

[11] Telephone conversation with Wayne Burdick. This tuning is done by carefully adjusting C50 to peak the output power.

23

Exhibit 23

Lead editorial from April 1998 *QST*

David Sumner, K1ZZ, made many of the points I have made in my comments. For example, he observes that CW encourages the development of technical skills because amateurs can construct their own CW transceivers. He points out that CW is important in amateur experimentation. He notes the higher levels of CW proficiency that currently dominate the amateur bands as compared to years past.

Particularly pertinent points are highlighted.

"It Seems to Us..."

The Joy of Morse

For now, the issue of the Morse code testing requirement for an HF license is settled. ARRL members were asked to consider whether or not to support the elimination of the requirement, and by a margin of better than two to one they favored the *status quo*. The ARRL Board of Directors has heeded this mandate.

About 30% of ARRL members disagree. That's a minority, but a substantial one: about 50,000 members. Some believe deeply that the League's position is wrong, and no doubt they will continue to work to change it. They are welcome to do so; representative democracy can be messy and even unpleasant at times, but if history has taught us anything it is that there is no good substitute for constructive discourse—for the mutually respectful clash of competing ideas. Meanwhile, it is important for all of us to remember that the issues on which we agree are far more significant than the ones on which we may disagree. It is fundamental that Amateur Radio as a whole needs to be promoted and defended, and the ARRL is the best means to that end; all else is secondary.

The League's position does not necessarily determine the issue. The Morse requirement is a part of the international radio regulations; these regulations are subject to the will of administrations, not of Amateur Radio organizations. But they have the force and effect of a treaty, and the earliest that administrations will even consider amending or eliminating the treaty document will be toward the end of the year 2001. Two or three more years would pass before any changes in domestic rules could take effect. In short, even those who support change must now accept that the peak of the new sunspot cycle will have come and gone before any change could possibly occur. It's time to move on to other matters.

The licensing requirement debate has obscured how CW is doing as an operating mode. To those who don't listen carefully to the parts of our bands where Morse is used, the answer may be surprising: it's doing very well indeed, even in the part of the spectrum for which it is no longer a licensing requirement. In his February column VHF columnist Emil Pocock, W3EP, discussed "The Necessity of CW" in exploiting unusual propagation modes, even in the world above 50 MHz. This month Jim McMasters, KD5BUR, describes a marriage of CW and computers to take advantage of the most fleeting, yet the most reliable, of VHF propagation phenomena: meteor scatter.

QRP—operating with 5 W or less—is an increasingly popular pursuit for which CW is particularly well suited. Tuning quickly across an HF CW band with your receiver set to an SSB bandwidth, you will miss the fact that there are scads of weak stations whose operators are happily pursuing a low-impact, minimalist approach to radio communication—often with equipment they have built themselves. Not only is it fun, it combines several of the best aspects of Amateur Radio: improvement of one's operating skills, technical self-training, and the development of an emergency communications capability.

CW contest operators can only chuckle when they hear of the impending demise of the mode. The fact is that scores keep climbing as both the number and the skill of participants continue to increase.

The ARRL staff regularly commissions random-sample member surveys to find out what you like and don't like about *QST*. The surveys also ask questions about your operating interests and activities. In a late 1997 survey, 46% of all respondents said they used CW regularly or occasionally. This places CW third in popularity among the operating modes, with FM at 78% and SSB at 74%. Among Extras, CW and SSB were tied for second at 78%, just behind FM at 81%. In other words, CW remains a strong second in popularity among HF operating modes, well ahead of everything but SSB.

Finally, if you read our mail you would be forced to conclude that amateurs who operate CW must enjoy Amateur Radio more than others. Complaints about rude behavior, inappropriate language and jamming almost invariably involve voice (and occasionally packet) modes, almost never CW. For many, simply chatting by Morse with old and new friends remains the core of Amateur Radio and a pleasant way to wind down after a hectic day.

But there's another side to this happy picture. While there are enough skilled CW operators among the Baby Boomers to keep the dits and dahs flowing for another three decades or more, recently those of us who enjoy this mode have not done a sterling job of motivating and assisting others in developing those same skills. We have permitted Morse to be seen as an unpleasant obstacle to be overcome, not as an enjoyable skill to be developed for its own sake. Except in a few local training nets, it is rare to hear poorly sent, slow Morse on the air any more. Paradoxically, that's not a good sign. CW operating is learned by practice, and you have to do it badly before you can do it well.

So, here is a challenge to accomplished CW operators and an invitation to other HF licensees. Sometime over the Easter weekend or at some other convenient time during the month of April, *get on the air* in the CW Novice bands. Maybe, invite a friend to join you in your shack. Keep your speed down. Seek out and encourage struggling operators. Don't collect contacts as if they were scalps. Rather, collect them as you would new acquaintances with whom you share a common interest.

If you're a newcomer to CW, no matter what your license class or how long you've been licensed, don't be afraid to make mistakes; that's what the Novice bands are for. We were all struggling beginners at one time, even if selective amnesia protects us from the memory of how truly awful we were!—*David Sumner, K1ZZ*

24

Exhibit 24

Deficiencies of 5 wpm CW testing

In my opinion, the ability to copy the Morse code at a speed of 5 wpm represents nothing more than the temporary, short term memorization of the dots and dashes of each Morse character. It does not represent even a minimal level of CW *proficiency*. A recurring experience, familiar to any long term amateur illustrates the point. In 1960 I learned to copy 13 wpm and obtained a general class license. Many of my contemporaries passed a 5 wpm test and obtained a novice license, but progressed no further. I never progressed much beyond the 13 wpm level and my license expired in 1965. During the next twenty-six years I had no exposure whatever to CW. In 1991, when I again took up the hobby, I was still able to copy better than 7 wpm. From time to time, I have had occasion to speak with some of my contemporaries from 1960 who never progressed beyond the novice level. In every such case, my contemporaries have admitted that **they have forgotten the Morse code completely**; that they no longer remember the dots and dashes for most of the letters of the alphabet. I believe that 5 wpm does not represent learning at all. The ability to copy 13 wpm, on the other hand, is like the ability to ride a bicycle.

The mechanics of testing at 5 wpm raise another problem. Five wpm is so slow that **I have seen examinees write down the dots and dashes** of many of the characters transmitted. After the code machine stopped, they filled in the characters at their leisure. Five wpm capability serves as a platform from which one can begin to achieve some level of real proficiency. It is nothing more. The ARRL's proposal to allow 5 wpm to be the final stage of CW development for general class amateurs is unwise. The proposal to allow amateurs with such a low level of demonstrated skill to operate CW outside the novice sub-band would certainly cause interference to weak signal intercontinental communications. These amateurs would not hear the weak signals. They would start call CQ and would not be able to understand when more skilled amateurs asked them to change frequency. We would have to look up their call sign and call them on the telephone to ask them to move. The interference that these amateurs would likely cause would result in international bad will; not good will.

Personally, I am glad that I was *required* to demonstrate 13 wpm and 20 wpm Morse proficiency. I would not have made myself learn that skill had the licensing structure not required it. Forced to develop the skill, I went from CW skeptic to CW enthusiast. CW has vastly enriched my amateur radio experience. **The FCC did me a favor** by denying me an amateur radio license unless and until I acquired the requisite CW skill. Thank you!

Exhibit 25

Heard in the novice CW sub-bands

In preparing to comment on the Notice of Proposed Rule Making, I have spent several hours monitoring activity in these sub-bands. I heard a significant amount of slow CW activity. By checking the call signs of the operators, I learned that licensees of all classes participate. The majority were general and advanced class amateurs. I also heard a number of technician plus amateurs. I even heard a few extra class licensees. Nearly all of the communications I heard was slow speed CW in the range of 5 to 10 wpm.

26

Exhibit 26

Census of amateurs by license class

This census was taken from the 1997 Radio Amateur Call Book.

CENSUS OF AMATEUR RADIO LICENSES* in the U.S.A.

by classes, within states and call areas

Call	State	Novice	Technician	Plus	General	Advanced	Extra	Club	Military	State Totals	Percent of Licenses
1	CT	1555	2449	862	1854	1482	1105	94	2	9403	1.31
1	MA	2126	4415	1525	3213	2606	2047	125	3	16060	2.24
1	ME	518	1268	467	1006	687	499	30	1	4476	.63
1	NH	532	1520	535	939	723	674	30	1	4954	.69
1	RI	381	728	310	524	362	347	31	1	2684	.38
1	VT	217	747	219	429	325	258	24		2219	.31
1	*TOTALS	5329	11127	3918	7965	6185	4930	334	8	39796	5.56
2	GU	164	240	53	63	47	52	2		621	.09
2	NJ	2451	4807	1834	3376	3042	2139	197	6	17852	2.50
2	NY	6087	10820	3618	6579	5532	3815	260	4	36715	5.13
2	VI	43	110	24	85	53	49	7		371	.05
2	AE	101	161	60	98	72	40			532	.07
2	*TOTALS	8846	16138	5589	10201	8746	6095	473	12	56091	7.84
3	DC	67	99	42	125	94	76	3	4	510	.07
3	DE	187	437	166	290	226	196	10	1	1513	.21
3	MD	1367	3452	1234	2216	2221	1495	85	7	12077	1.69
3	PA	3235	7332	2705	5078	4391	3076	198	12	26027	3.64
3	*TOTALS	4856	11320	4147	7709	6932	4843	296	24	40127	5.61
4	AL	943	4105	1099	1747	1651	1157	56	2	10760	1.50
4	FL	6323	11527	4072	9169	7612	4356	174	4	43237	6.04
4	GA	1387	5020	1474	2594	2534	1583	85	3	14680	2.05
4	KY	1104	3309	937	1456	1199	914	54	1	8974	1.25
4	NC	1885	6125	1918	3097	2887	1910	89	2	17913	2.50
4	PR	4121	2103	1012	803	586	288	18	1	8932	1.25
4	SC	632	2129	697	1347	1076	721	80	2	6684	.93
4	TN	1357	4990	1570	2299	2292	1529	67	3	14107	1.97
4	VA	1880	5100	1900	3045	3022	2119	79	5	17150	2.40
4	AA	25	47	12	28	9	8		1	130	.02
4	*TOTALS	19657	44455	14691	25585	22868	14585	702	24	142567	19.93
5	AR	576	2556	703	1062	1044	761	38	1	6741	.94
5	LA	830	2418	708	1375	1320	839	43	3	7536	1.05
5	MS	506	1669	440	847	798	499	23	2	4784	.67
5	NM	329	1914	470	880	881	595	29		5098	.71
5	OK	1027	3621	854	1461	1480	949	50	1	9443	1.32
5	TX	4037	14479	4044	7632	7457	4789	227	8	42673	5.96
5	*TOTALS	7305	26657	7219	13257	12980	8432	410	15	76275	10.66
	CA	15734	41781	10528	16107	15264	8757	764	16	108951	15.23
6	HI	665	1097	279	560	490	320	46	3	3460	.48
6	AP	107	172	53	73	44	40	2	7	498	.07
6	FM	1							1		.00
6	MP	8	76	9	19	20	36	3		171	.02
6	PW	·				1			1	2	.00
6	TT	1				1	2			4	.00
6	*TOTALS	16516	43126	10869	16759	15820	9155	815	27	113087	15.80
7	AK	408	1059	247	627	499	327	13	6	3186	.45
7	AZ	1162	5639	1572	2643	2514	1547	56	2	15135	2.12
7	ID	374	1435	401	716	590	335	20		3871	.54
7	MT	337	963	301	580	466	304	23		2974	.42
7	NV	346	1484	450	843	679	414	25		4241	.59
7	OR	1427	4077	1360	2696	2097	1262	74	1	12994	1.82
7	UT	705	4022	774	772	816	503	22	2	7616	1.06
7	WA	2851	8528	2564	4433	3670	2443	106	4	24599	3.44
7	WY	199	554	180	291	233	186	11		1654	.23
7	*TOTALS	7809	27761	7849	13601	11564	7321	350	15	76270	10.66
8	AS	11	51	10	9	5	10	4		100	.01
8	MI	2368	7095	2175	4212	3521	2250	139	1	21761	3.04
8	OH	3696	11070	3708	5458	4811	3163	221	1	32128	4.49
8	WV	746	2567	658	925	729	596	31	4	6256	.87
8	*TOTALS	6821	20783	6551	10604	9066	6019	395	6	60245	8.42
9	IL	3270	7564	2441	4655	4078	2621	172	13	24814	3.47
9	IN	1887	5347	1702	2720	2325	1518	124		15623	2.18
9	WI	1171	3414	985	2151	1826	1189	64		10800	1.51
9	*TOTALS	6328	16325	5128	9526	8229	5328	360	13	51237	7.16
10	CO	1222	3844	1225	2124	2067	1256	54		11792	1.65
10	IA	989	1894	606	1457	1369	740	50	2	7107	.99
10	KS	921	2439	799	1530	1139	740	67	1	7636	1.07
10	MN	1188	3278	1088	2271	1953	1181	82	1	11042	1.54
10	MO	1413	4050	1269	2581	2211	1428	83	1	13036	1.82
10	ND	227	550	156	367	242	166	12	1	1721	.24
10	NE	448	1110	412	949	760	394	36		4109	.57
10	SD	165	441	135	352	296	173	15		1577	.22
10	*TOTALS	6573	17606	5690	11631	10037	6078	399	6	58020	8.11
	*FINAL	90173	235640	71681	126978	113240	73064	4534	152	715462	100.00
Percent of total licenses		12.60	32.94	10.02	17.75	15.83	10.21	.63	.02		

3b

Exhibit 30

High frequency digital modes tested

This article from the July 1996 issue of *QST* demonstrates that a shake out is coming in these technologies. After the shake out, the FCC should consider adding questions to the question pool. Those questions should cover the technologies that survive and thrive, if any of them does.

By Tim Riley; Dennis Bodson, W4PWF; Stephen Rieman; and Teresa G. Sparkman

A Comparison of HF Digital Protocols

The world of HF digital communication is a confusing mix of protocols. Which offer the best performance?

In recent years our HF digital subbands have become Towers of Babel with several protocols competing for dominance. The familiar list includes AMTOR, G-TOR, CLOVER, PACTOR and PACTOR II.[1] Each mode has its enthusiastic supporters, but which ones are most efficient when it comes to transferring information?

The task of evaluating HF digital protocols is more than just an academic exercise. Our government has a stake in determining the answers because HF digital operators have traditionally supplied a large reservoir of backup communications services and operators during emergencies. In the interest of tapping this resource, the National Communications System (NCS) sponsored the National Telecommunication and Information Administration (NTIA) to test various HF modems and establish a technical baseline of standardized performance data on HF modem protocols. The Federal Emergency Management Agency (FEMA) will use those test results to determine which protocols could be used to serve as an interchange with the amateur community in the event of a national emergency. This article reflects the results of tests conducted at NTIA's Institute for Telecommunication Sciences (ITS) laboratories in Boulder, Colorado.

Solving the Propagation Problem

Many over-the-air tests have been conducted on various HF modem/protocol combinations. Atmospheric conditions vary so much, however, that it's impossible to draw solid conclusions. Over-the-air test results can change from day to day, or even hour to hour. To obtain scientifically valid information, you need stable conditions. Unfortunately, Mother Nature refuses to guarantee the stability of HF propagation!

So, we turn to the laboratory, where it's possible to create elaborate *simulations* of HF propagation paths. The engineers at ITS have developed an automated test bed for use in conducting controlled laboratory testing of modems and their protocols. Using this test bed, ITS subjected the protocols to a repeatable set of simulated propagation paths over a wide range of signal-to-noise ratios (S/Ns).[2]

Data transfers were performed at various S/Ns for each of the five protocols in their Automatic Repeat Request (ARQ) mode. All files received were checked for errors to determine the validity of the tests. The *throughput*, a measure of the data transfer rate, was measured for each protocol under simulated ionospheric conditions.

To conduct our tests we obtained HF modems manufactured by Kantronics, HAL Communications, Advanced Electronic Applications and SCS. However, specific models are not identified in this article. You'll see them referred to as modems A through D only. The intention is to evaluate protocols, not hardware. It is important to note that the use of specific hardware does *not* imply a recommendation or endorsement by the National Telecommunications and Information Administration, nor does it imply that the equipment used is necessarily the best available for this application.

Test Conditions

For each test, two identical modems (see Table 1), controlled and monitored by one 80486-based PC, were physically connected to each other by their audio-out/audio-in ports through two identical HF ionospheric channel simulators (Figure 1). Although the modems were both connected to the same PC, the operation of one was entirely independent of the other.

The modems were linked to the computer through the PC's serial communication ports (COM1 and COM2), except for the CLOVER

Table 1
HF Protocols Tested

Note: The AMTOR and PACTOR protocols were tested on two modems to determine if there were implementation differences in the results. The other three protocols were implemented by unique modems. Modems are identified simply as A, B, C and D.

Protocol	*Modem*	*Computer Interface*
AMTOR	A and B	Serial port
CLOVER	C	PC bus (plug-in card)
G-TOR	D	Serial port
PACTOR	A and B	Serial port
PACTOR II	A	Serial port

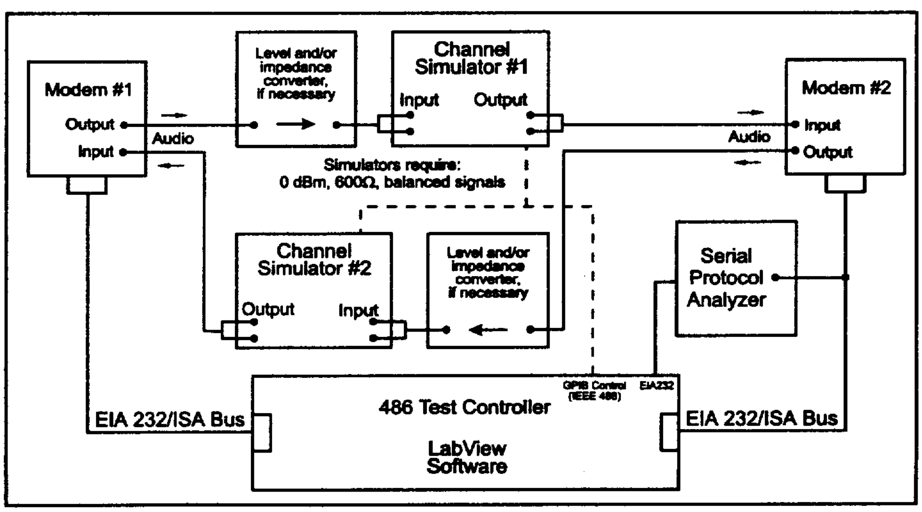


Figure 1—Block diagram of the HF modem test setup.

[1]Notes appear on page 39.

Exhibit 31
Discussion of CW and written testing

CW testing. I have heard extra class amateurs admit they "squeaked by" the Morse code requirement under a multiple guess quiz. Some call themselves "no code extras." They admit that they did not have the proficiency that the current standards seek to require. Therefore, I believe that the Commission should mandate certain testing procedures. Most VE's perform their duties with distinction, but a few have demonstrated that they should not be trusted to set their own standards for CW testing. The simplest solution is to adopt the time tested one-minute-solid-copy standard. Such a standard would be sufficient in and of itself. However, the integrity of the testing procedure can be ensured with fill in the blank or even multiple guess questions, but only if more comprehensive testing mechanics are mandated. The governing factors are: (1) the difficulty of the copy transmitted; (2) the difficulty of the questions asked; and (3) the minimum passing score.

It is current practice to transmit very simple copy. It universally takes the form of a simple "QSO" or CW contact, as illustrated below:

> (Call sign) DE (call sign). TNX FOR THE CALL. YOUR RST IS 579 (or similar report). MY NAME IS (name). MY QTH IS (city, state). THE WX HERE IS (weather report) AND THE TEMPERATURE IS (number of degrees) F. MY RIG IS (name or description of transceiver) AND I AM RUNNING (number of watts) WATTS. MY ANTENNA IS (description of antenna) UP (number of feet) FEET. NOW I HAVE TO QRT TO (reason for quitting). 73 ES CUL. (Call sign) DE (call sign) AR SK

The questions will invariably be in like the following: What is the call sign of the transmitting station? (Note that call signs are transmitted twice.) What is the name of the transmitting operator? What is his QTH? What is the weather (WX) at the QTH? What is the temperature? And so forth. The examinee knows to concentrate on the RST, name, QTH, WX, rig, etc. He knows these will be the questions. This kind of testing is useful in that the amateur learns exactly how to begin a real contact. It is also extremely easy. The Commission might (1) require the transmission of character groups instead of text; (2) specify that the QSO format *not* be used; (3) specify readability statistics for the copy. Copy can be checked against such readability statistics by running the grammar checking routines contained in various word processing software, such as Microsoft Word.

Correct answers should meet certain criteria such as average and minimum length in characters, number of times the information was transmitted, the use of random character groups such as call signs, and the like. For multiple guess testing, the FCC should specify the minimums number of distracters and require that all distracters be plausible answers containing some of the same characters as the correct answers.

Finally, the FCC should specify a minimum passing grade. For multiple guess testing, the minimum should be higher than for fill in the blank in order to neutralize correct answers that occur by pure guess.

Written testing. As currently administered, the written examinations are, at best, an opportunity for a motivated individual to learn something about technical and operational theory. For less motivated individuals, the written examination is simply a memorization and guessing experience. I believe that the mechanics should be changed to *ensure* that the examinee has mastered a significant level of theory, and that he has not simply memorized most of the answers from the published question pool. I recommend that the Commission make the following changes: (1) Increase the minimum score needed to pass the exam. (2) Mandate that all questions requiring a mathematical computation (and perhaps certain other questions) be of the fill in the blank variety. In the case of such questions, the published question pool should not contain the exact question and answer, but rather a sample question and answer, or a general statement of the nature of the question to be asked and a discussion of the nature of a correct answer. (3) Reinstate the drawing of schematic diagrams. Learning to draw these diagrams is a useful learning tool for technical theory.

Minimum grade. A grade of 74 ('D') on multiple guess indicates that the examinee knew 65 percent of the correct answers(clearly, an 'F'). That assumes that all distracters are effective. To ensure that an examinee has demonstrated 74 percent comprehension of the material tested, the minimum passing grade should be increased to 81 percent. Again, this assumes that all distracters are effective. In my opinion, no one should be awarded an amateur radio license who cannot score at least 81 percent on a multiple guess examination.

Diagramming. I know that the VE's will resist the reinstitution of schematic diagramming. In the NPRM, the Commission expressed concern for the burden on VE's. I believe that such concern is misplaced. In 1991, I had the opportunity to take a VEC test on an average of once per week. VEC's operating in the area competed with each other, actually advertising for business in local amateur newsletters. There is a VEC examination at every hamfest. Testing opportunities swamp the demand. During my own testing and the testing of my wife Shelley (who advanced from tech plus to amateur extra one step at a time), I learned that many amateurs enjoy the hobby exclusively through their VE activities. Being a VE is their only amateur radio activity. It is the way they enjoy the hobby. Except for the most popular testing sessions, the VE's often don't have enough to do. I believe that the VEC's are fully capable of ensuring that VE's can grade tests that include schematic diagramming.

Attached is an example of pages from a popular W5YI study guide for the advanced class license. It was authored by Gordon West. Students are admonished to remember the difference between the schematic symbols for a PNP and an NPN bipolar transistor by using an easy memorization technique not related in any way to technical theory. "PNP" is said to stands for "pointing in part;" NPN stands for "not pointing in." The emphasis in such study techniques is not on learning theory, but on passing the exam through rote memorization. Fill in the blank questions and schematic diagramming will help to put the emphasis where it belongs: on learning theory.

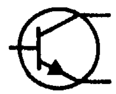
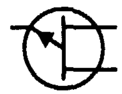
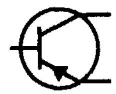
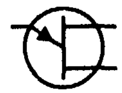
ANSWER C: PIN diodes may be used in small handheld transceivers for RF switching. This gets away from mechanical relays for switching.

4AF-1.20 What special type of diode is often used in RF switches, attenuators, and various types of phase shifting devices?

A. Tunnel diodes
B. Varactor diodes
C. PIN diodes
D. Junction diodes

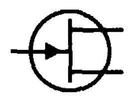
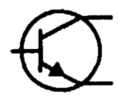
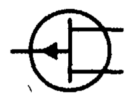
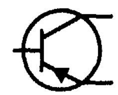
ANSWER C: The PIN diode may also be used in attenuators, along with RF switching.

4AF-2.1 What is the schematic symbol for a PNP transistor?

A.  B.  C.  D. 

ANSWER C: Remember this on your Novice Class examination? Which way is the arrow pointing? If it's *pointing in*, it is PNP—"P in."

4AF-2.2 What is the schematic symbol for an NPN transistor?

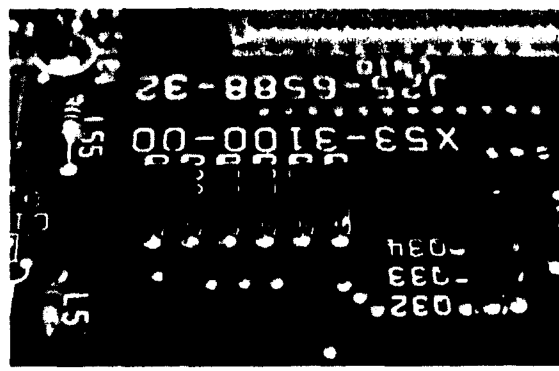
A.  B.  C.  D. 

ANSWER B: Here the arrow is *not pointing in*, NPN,—"Not P in."

4AF-2.3 What are the three terminals of a bipolar transistor?

A. Cathode, plate and grid
B. Base, collector and emitter
C. Gate, source and sink
D. Input, output and ground

ANSWER B: Almost like the alphabet, B for base, C for collector, (skip D), and E for emitter.



Transistors Mounted in Circuit Board